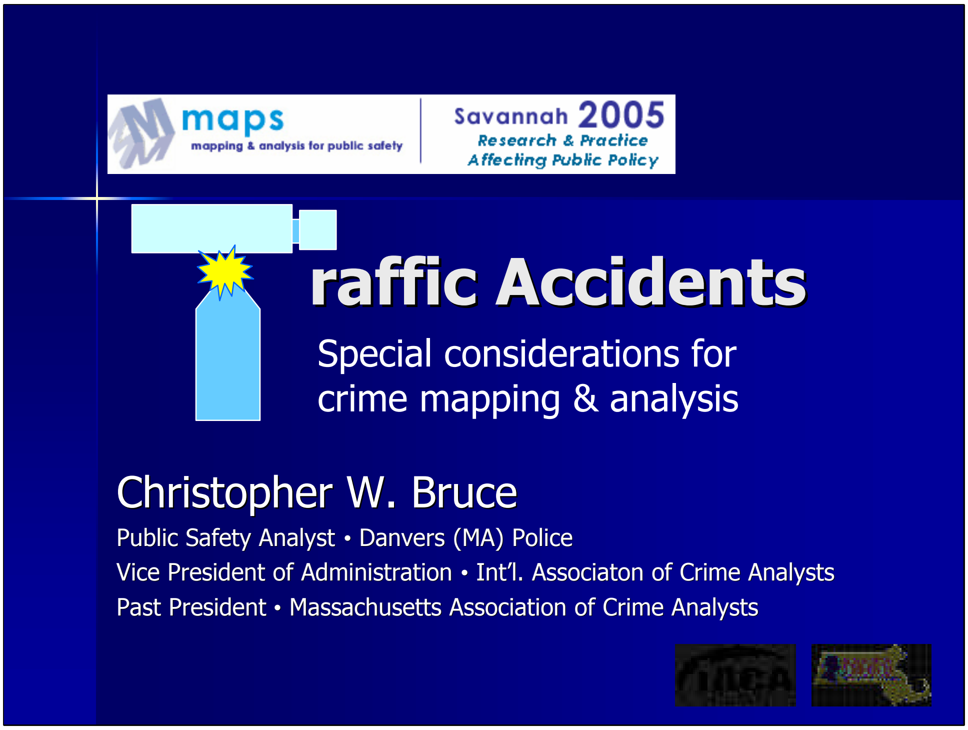
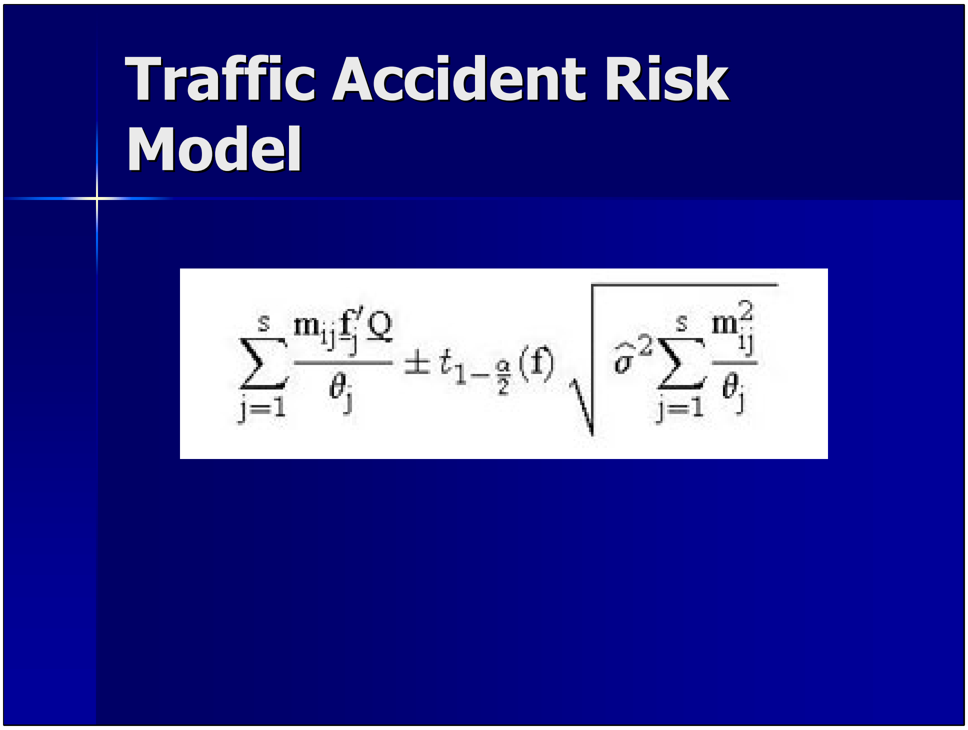
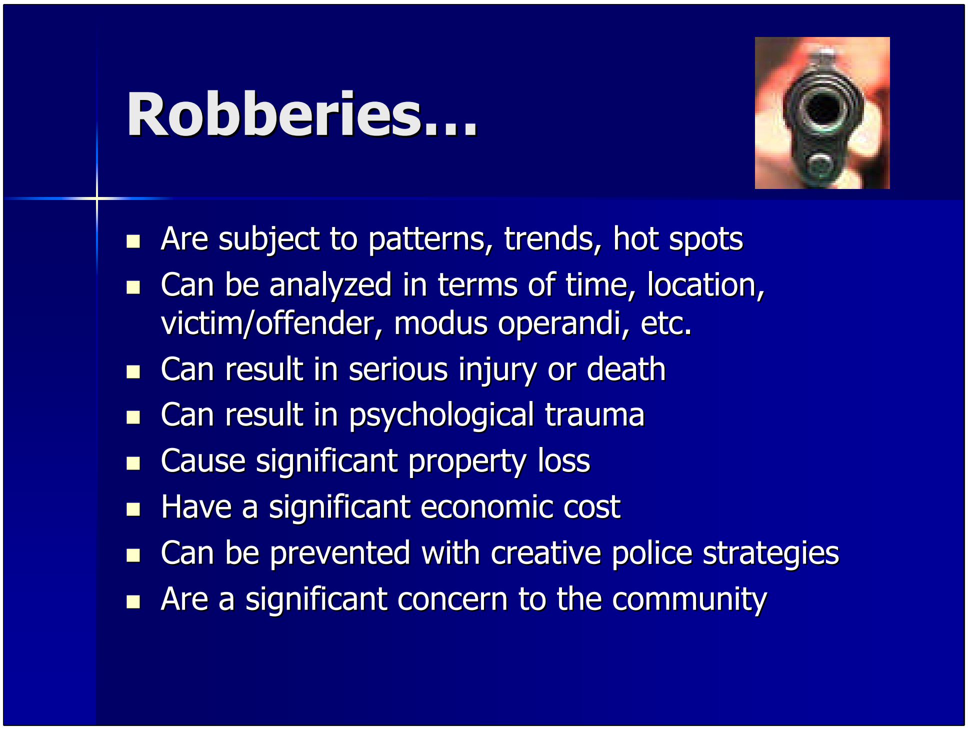


Good day to those of you reading this presentation. This is an annotated version of a presentation I gave at the 2005 MAPS conference in Savannah, Georgia. I am Christopher Bruce, a crime analyst with the Danvers (MA) Police Department. In my role as an analyst for a fairly small town, I am expected to deal with a number of non-crime issues, including traffic accidents.



This was a joke. My presentation was the last one of the conference, and I put this slide up on the screen just to watch the expressions of the exhausted attendees. If anyone out there knows what this model actually represents, e-mail me at cbruce@mail.danvers-ma.org and I'll be suitably impressed.

I used this slide to discuss the differences between my approach (and my presentation) and some of the other presentations at the conference. My material is not high-tech, academic, or necessarily very complicated. It represents what a local-level analyst can do with local-level resources and funding.

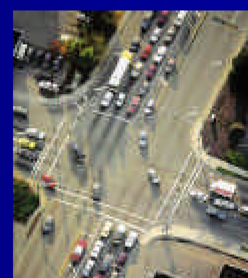


Most crime analysts do not deal with traffic accidents. Instead, as their title suggests, they deal with crime—such as robberies. As we see from this slide, robberies have a number of characteristics that make it right and proper for an analyst to spend time on them…

…but traffic accidents also share all these same characteristics. More important, accidents occur every day. In some jurisdictions, robberies occur every day, too, but never in the same volume as traffic accidents.

Addressing Crime/Accidents

- Directed Patrol/Enforcement
- Environmental Re-Design
- Community Information
- Targeted Intervention to "Risk Groups"
- Etc.

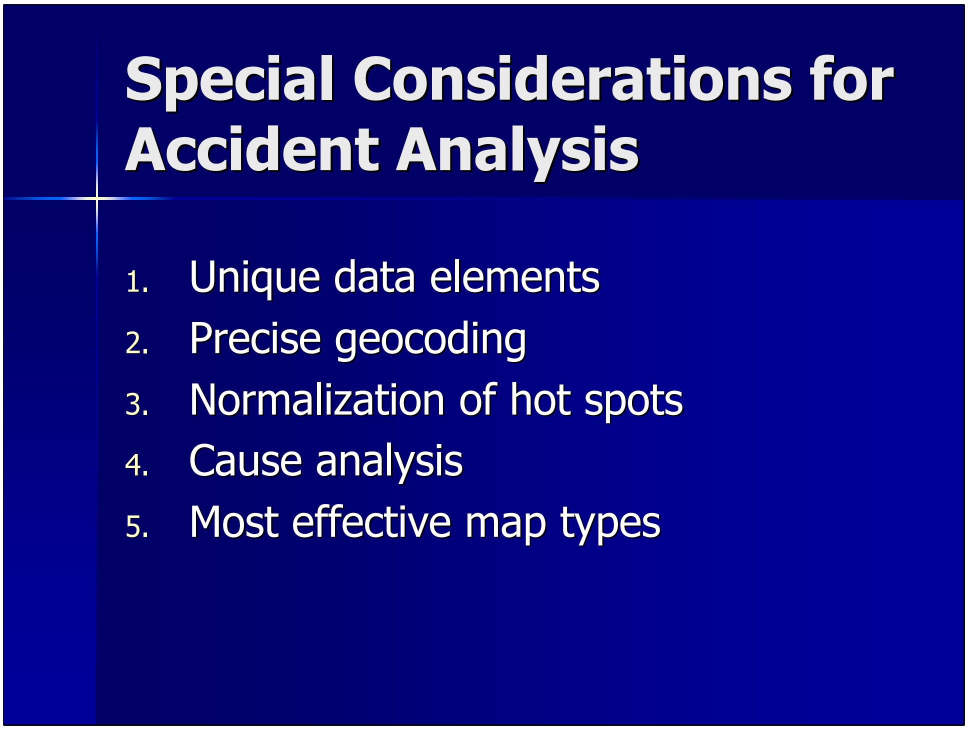


Crime and accidents are also similar in the means used to address them. These are just some strategies that apply to both crime and traffic accidents.

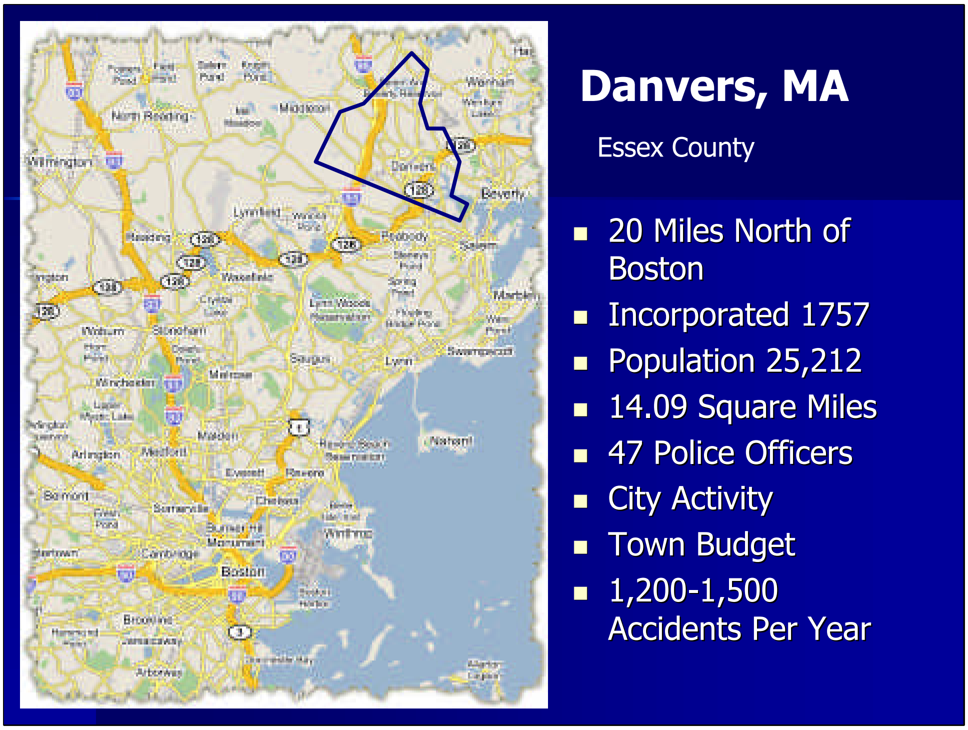
Situational Crime Prevention and Accidents

Control "Tools"	Licensing rules, tests
Extend Guardianship	Targeted enforcement of high-accident locations
Deny "Benefits"	Speed bumps
Post Instructions	Speed limit signs, "stop light ahead"
Alert Conscience	"21 Fatal Accidents Next 16 Miles; headlights on at all times"

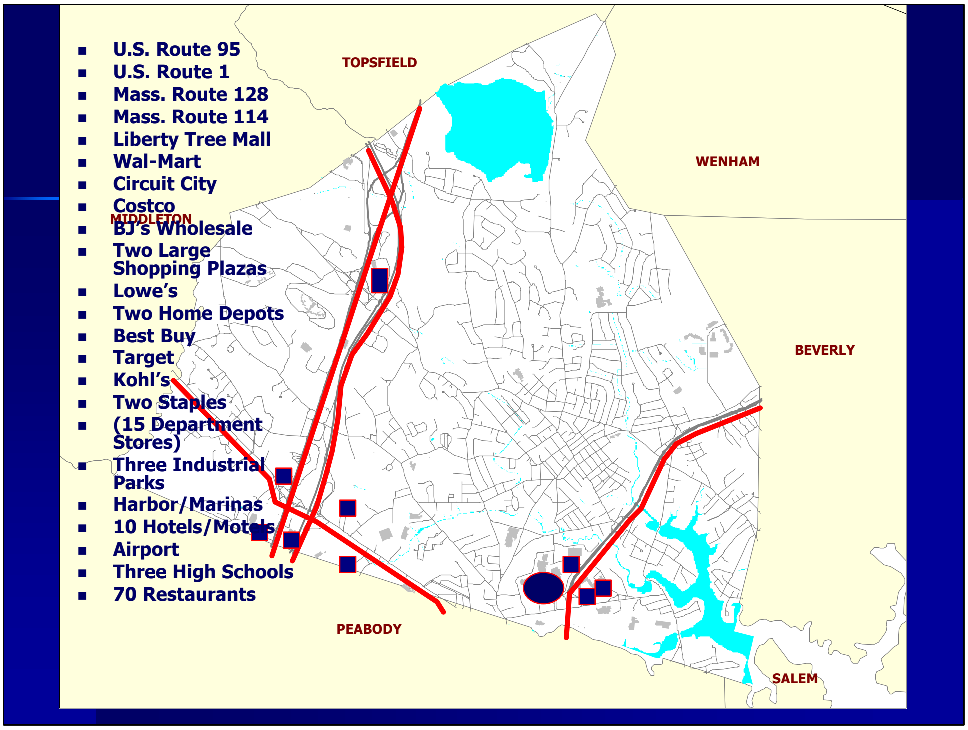
Moreover, the 25 techniques of Situational Crime Prevention (see www.popcenter.org) almost all have some applicability to traffic accidents, especially considering that many accidents are caused by "crimes" such as speeding and drunk driving. These are just a few examples.



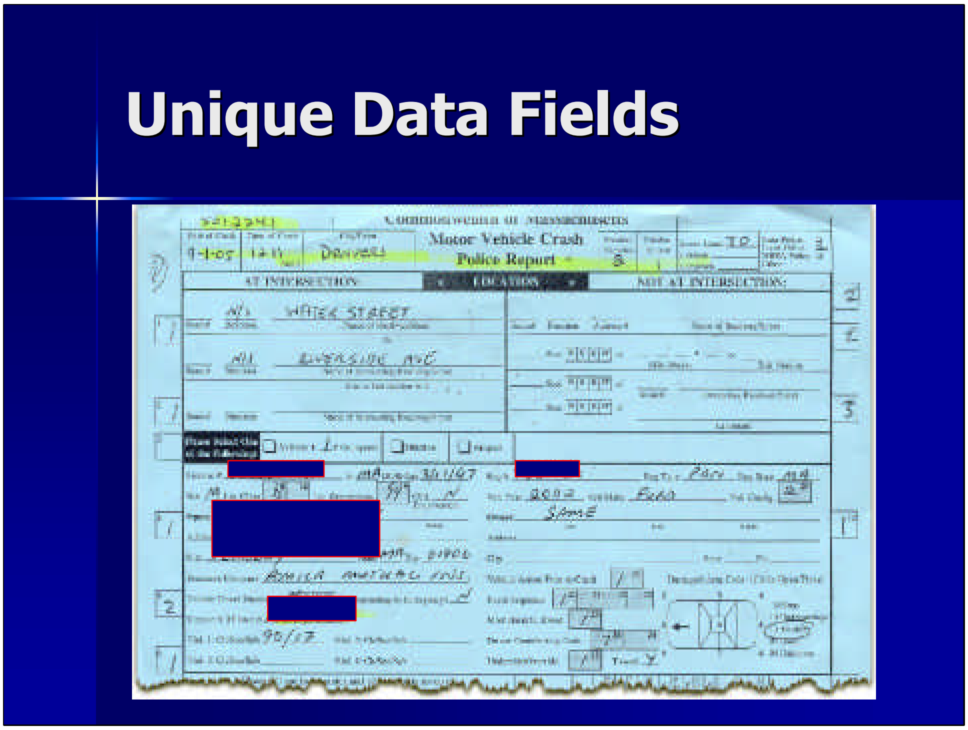
But traffic accidents have some unique considerations that make them different from crime. First, accident reports contain a number of unique data elements that don't have direct analogs in crime reports. Second, I would argue that accident analysis, especially at the town level, requires much more precision in geocoding than we have become accustomed to using with crime. To fully understand "hot spots," we must be able to normalize by traffic volume. Cause analysis, while an important part of crime analysis, has unique implications for traffic accidents. Finally, the types of maps used to depict traffic accident hot spots are not necessarily the same as the types of maps used to depict crime hot spots.



Before we go further, here are some characteristics of the town I work for. As you can see, it’s a fairly small town north of Boston (the geographic size may seem miniscule to many of you, but actually it’s about average for Massachusetts towns). But we have a lot more accidents than you might expect for a town of its size. Why is that?

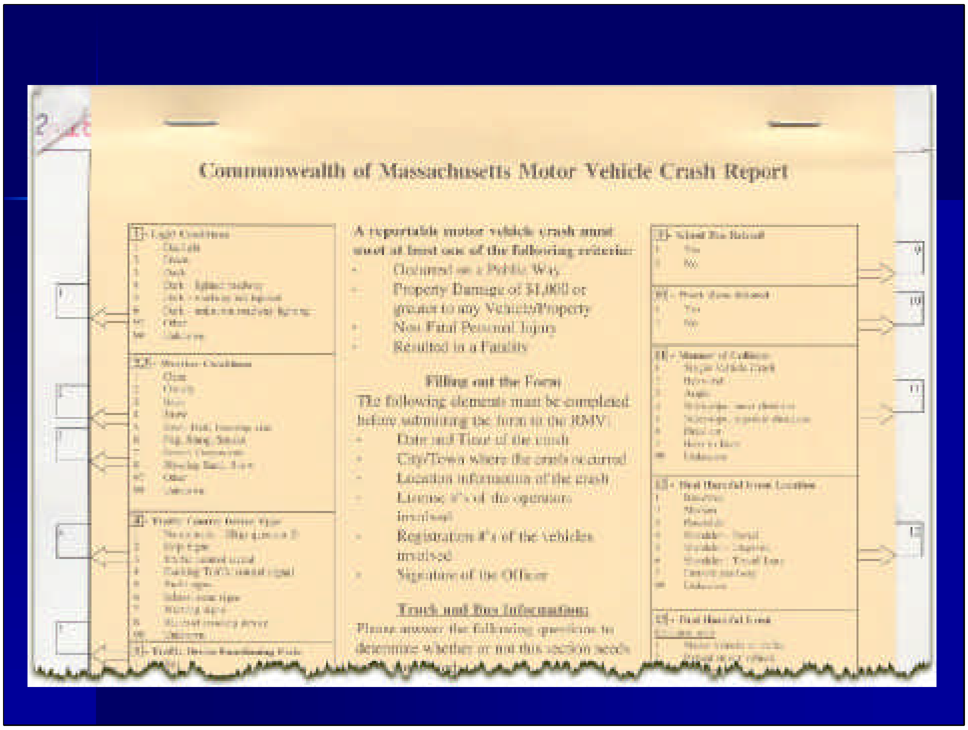


Here are some of the reasons. We have two major U.S. highways and numerous state routes running through town. There are 15 department stores, numerous industrial parks, a major shopping mall, a harbor, an airport, numerous restaurants and auto dealerships, and so on. Danvers has the population of a small town but the activity of a mid-sized city. This leads to the elevated accident rate that the extra traffic causes.



We now move into a discussion of the unique data fields that traffic accident reports contain. At this point, I want to mention that in my own agency, traffic accident reports are not computerized. To get these fields, I must enter them in my own custom database.

Note that in Massachusetts (as in many other states), accident reports are called "crash reports." I refuse to use this term.



Commonwealth of Massachusetts Motor Vehicle Crash Report

A reportable motor vehicle crash must meet at least one of the following criteria:

- Occurred on a Public Way
- Property Damage of $1,000 or greater to any Vehicle/Property
- Non Fatal Personal Injury
- Resulted in a Fatality

Filling out the Form

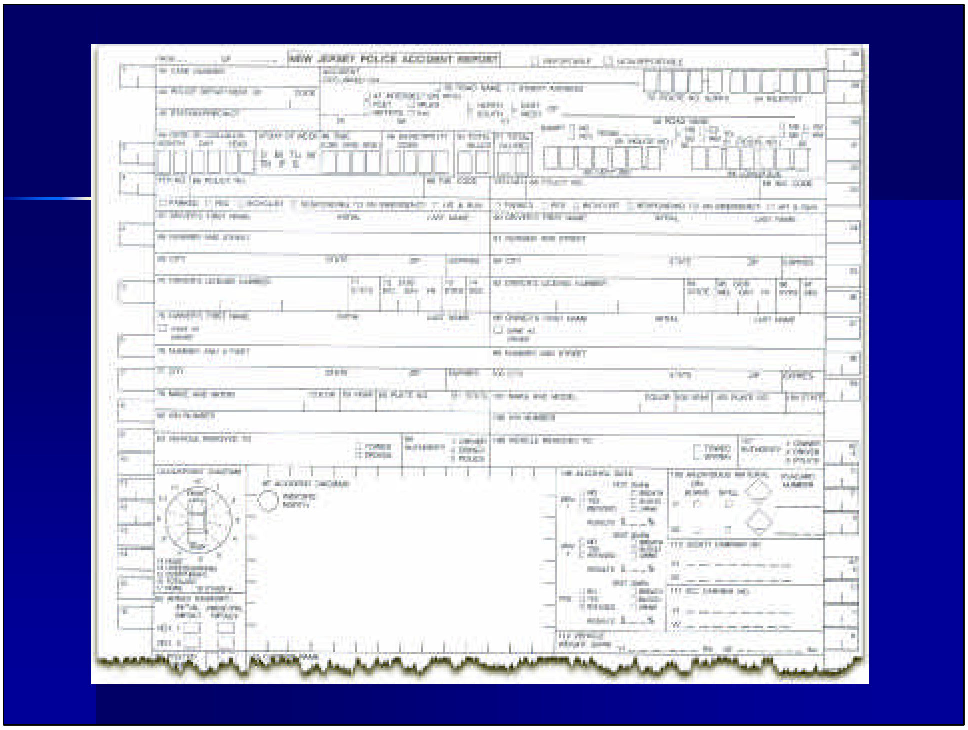
The following elements must be completed before submitting the form to the RMV:

- Date and Time of the crash
- City/Town where the crash occurred
- Location information of the crash
- License #'s of the operators involved
- Registration #'s of the vehicles involved
- Signature of the Officer

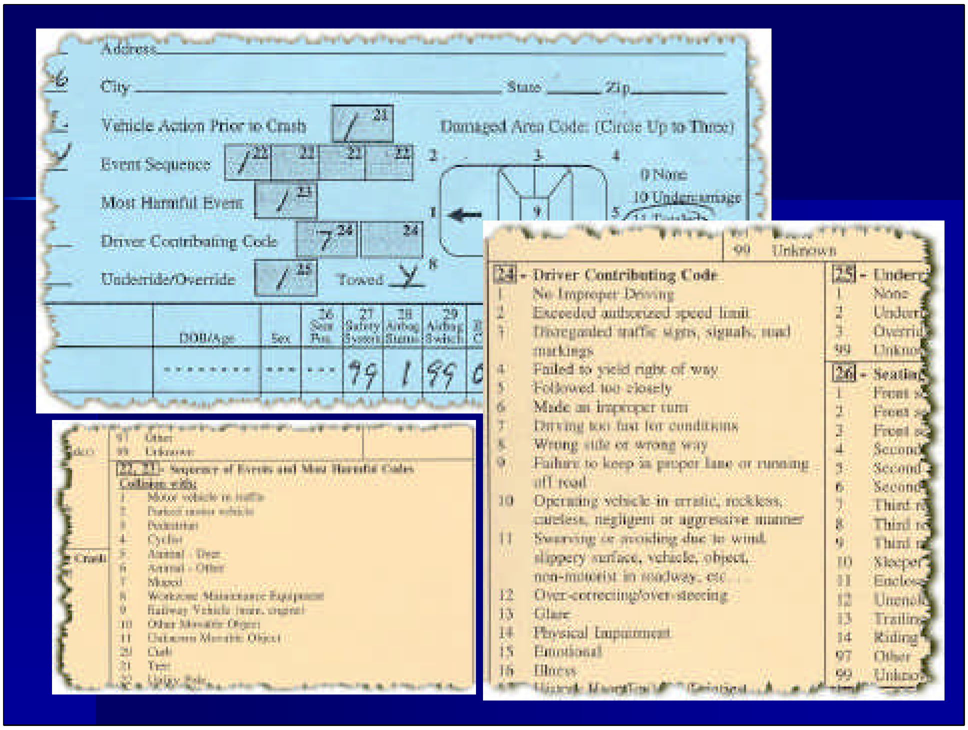
Truck and Bus Information:

Please answer the following questions to determine whether or not this section needs

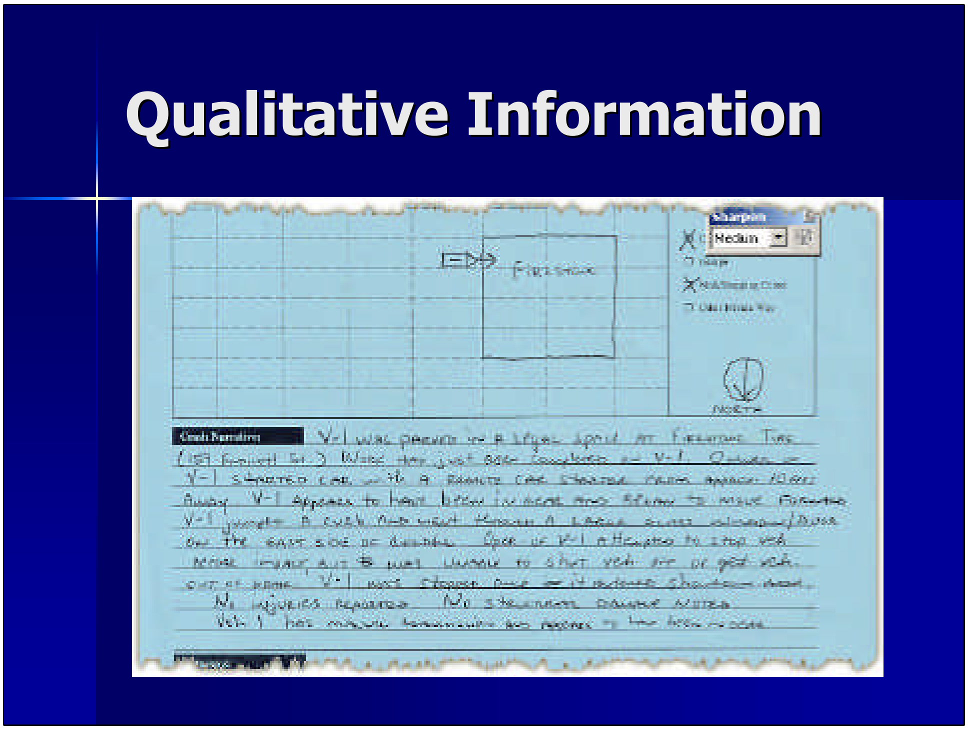
We see here how in some states, officers use a code overlay that helps them enter values into boxes along the edges of the form. These boxes track data such as weather conditions, the type of accident, and any traffic control devices present.



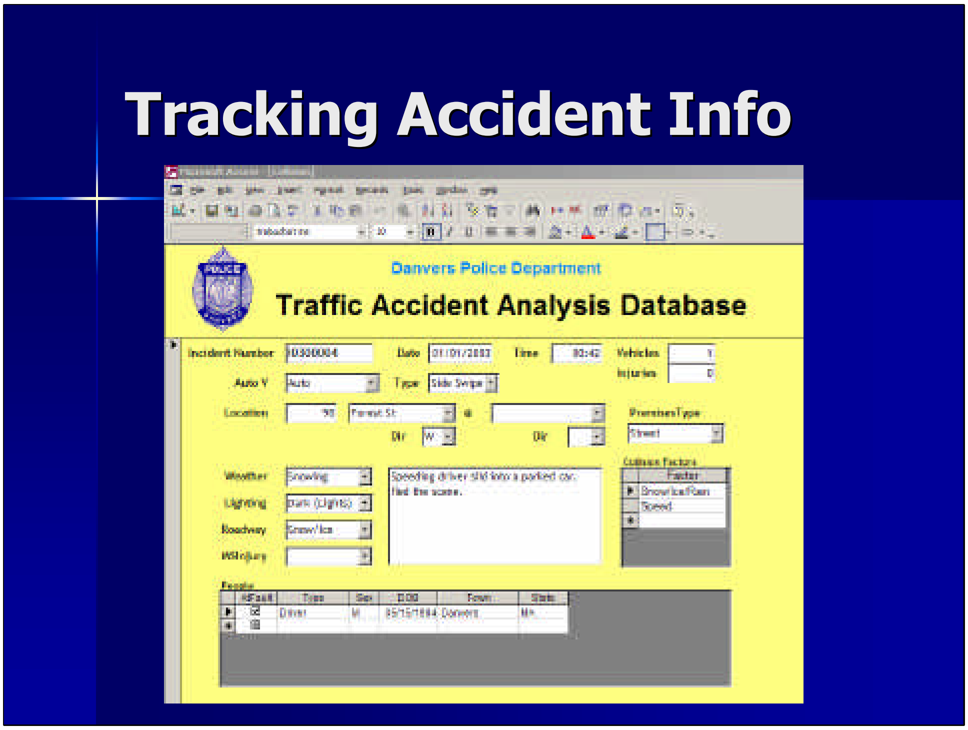
New Jersey has essentially the same report design. One analyst there described the report as being “designed by insurance companies.”



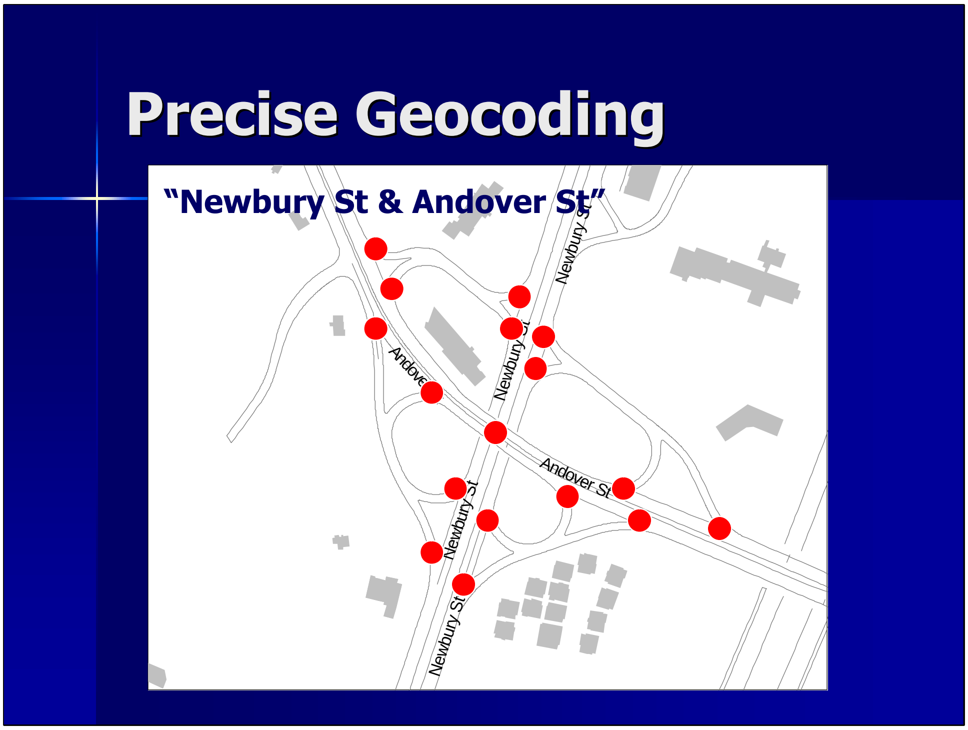
Here we have a close-up view of the section of the report that deals (in part) with the cause of the accident. The “driver contributing code” on this specific report indicates that the driver was speeding.



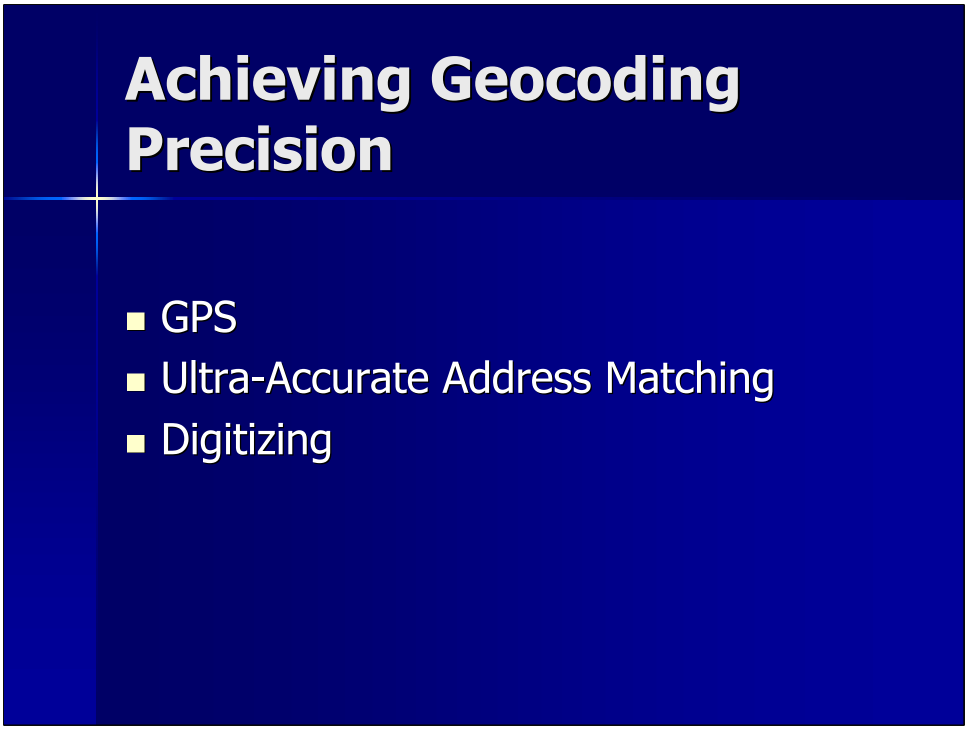
Much of the information we glean from accident reports is qualitative. In this case, the accident occurred when a patron of Firestone started his car with a remote starter. The car was in gear and went through the Firestone window. No combination of discrete fields would have alerted us to this particular "cause"; just like with crime, it is often important to read the narratives to get a true sense of what happened.



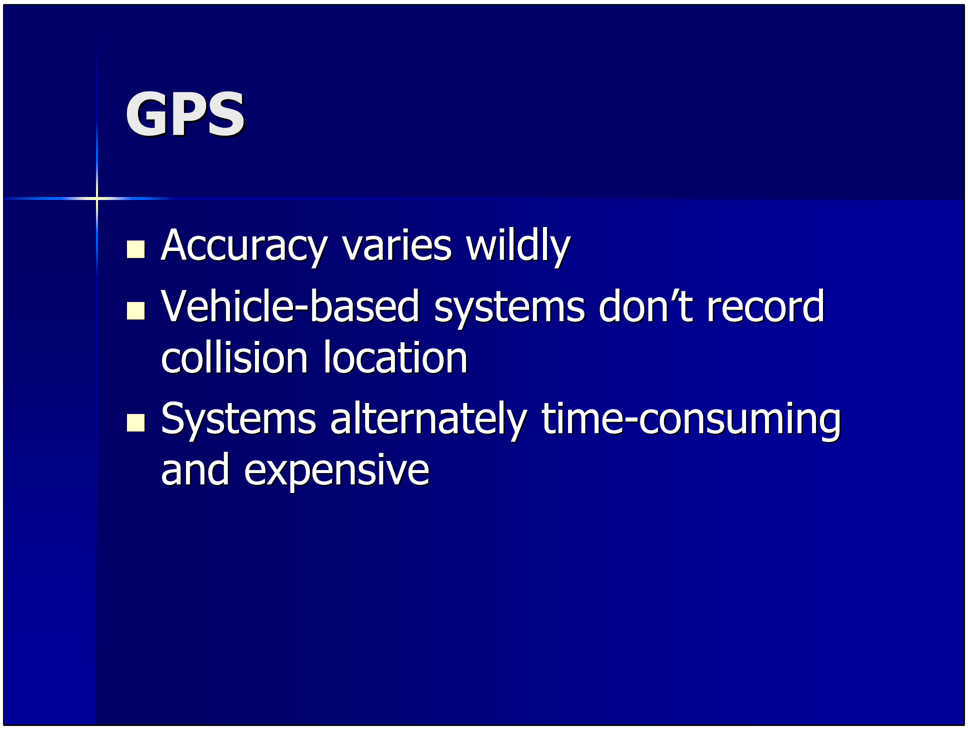
Again, since my data isn’t computerized, I’ve had to compensate by creating a custom database to track accident data. Interns handle most of the data entry. Please note that I am color blind and therefore can’t be held responsible if the form’s background color is offensive.



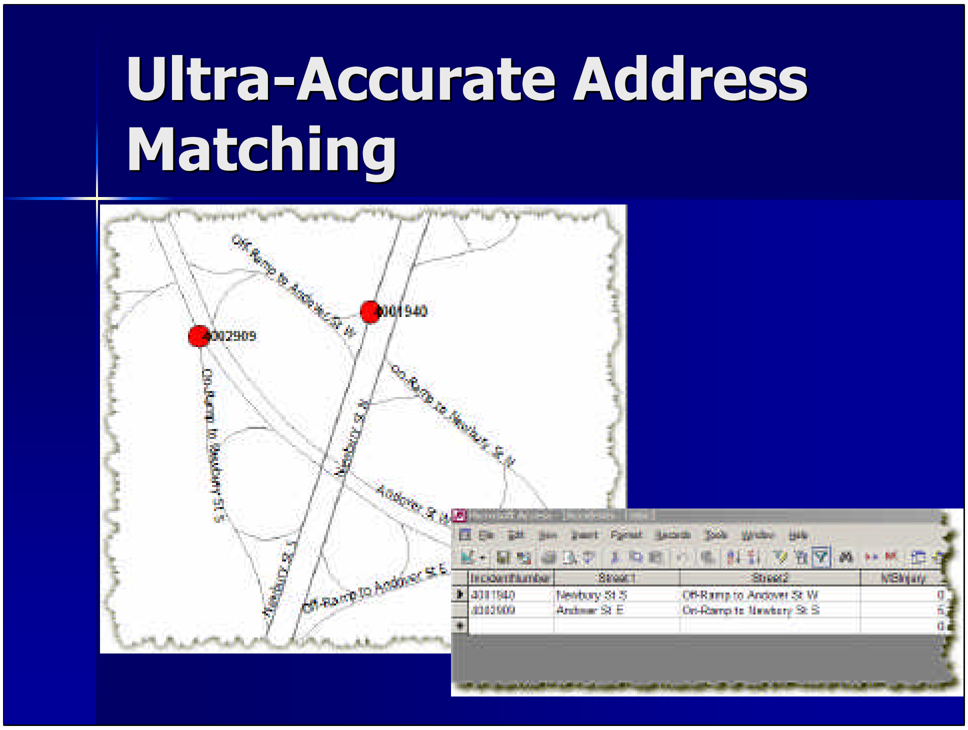
Precise geocoding in traffic accidents is important. On this slide, we see the "intersection" of Newbury Street (U.S. Route 1) and Andover Street (state Route 114) in Danvers. There are many, many accidents in my database that have "Newbury St & Andover St" as the address. But as we see from this map, "Newbury St & Andover St" may refer to any one of more than a dozen locations on the various on- or off-ramps from both roads, as well as the physical crossing of them. If we have a "hot spot" here, it's important to know whether the accidents are concentrated on a particular ramp, or on one side of a divided route. Address matching just doesn't do it for us.



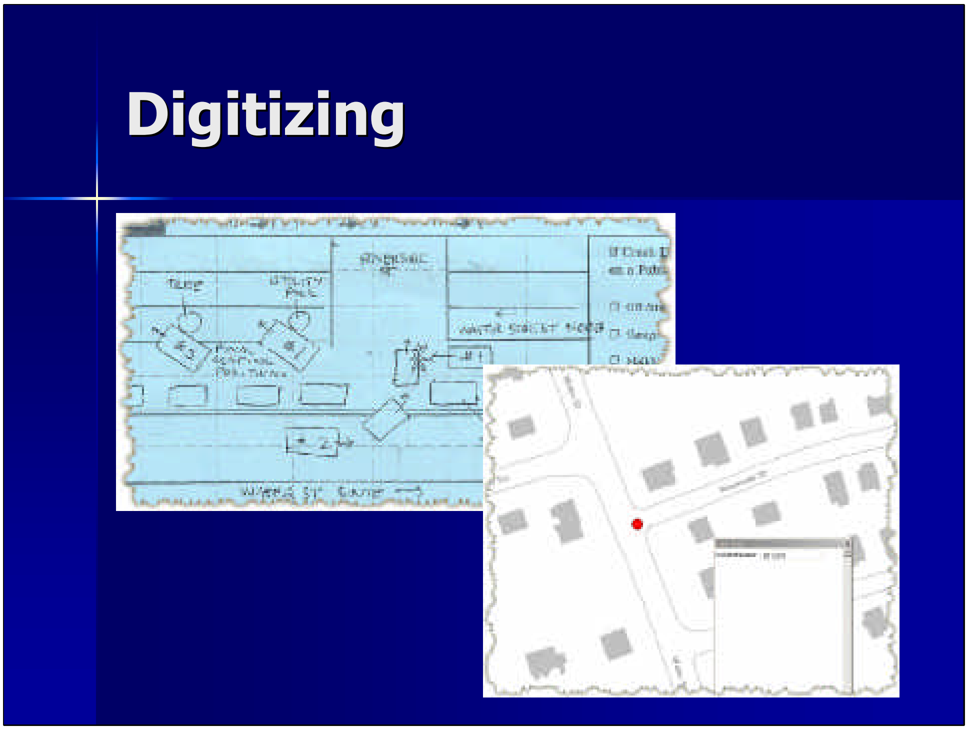
There are three ways to achieve better precision: recording geographic coordinates with GPS, pursuing “ultra-accurate address matching” (more in a moment), and digitizing. These are all discussed here.



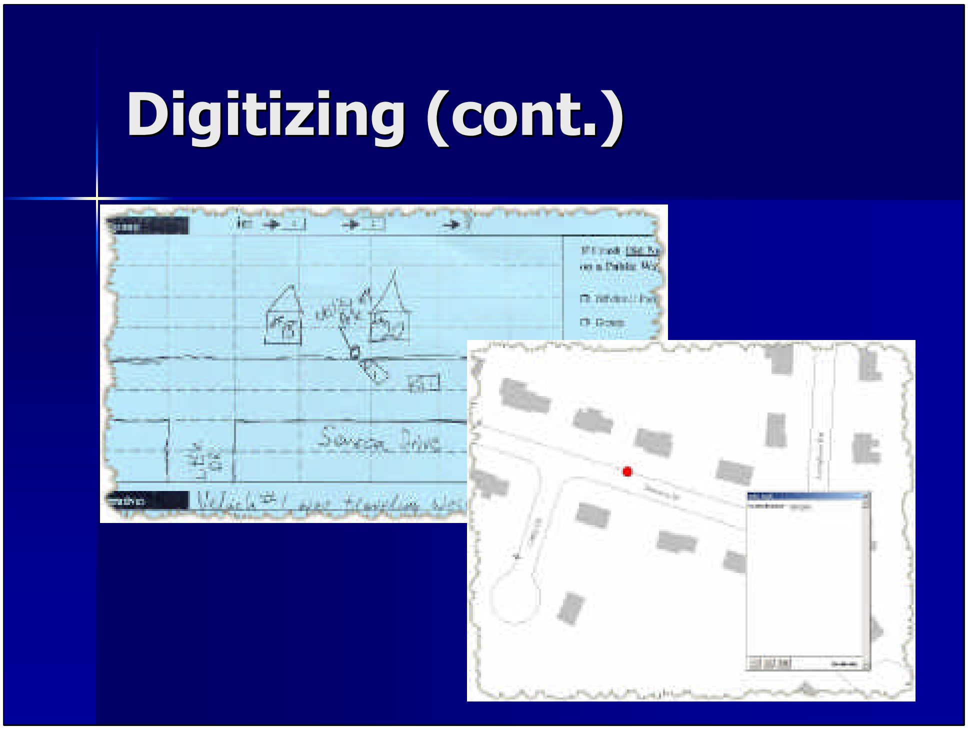
GPS seems like it might be the best way to go about it, but remember that accuracy varies considerably, depending on the presence of buildings, clouds, and other temporary glitches in the system. While sub-meter accuracy is theoretically possible, the fact is that most GPS units don't give the user much indication of how "accurate" the current reading is. Consequently, an officer with a GPS unit at an accident scene may in fact record a location several meters away—enough to throw the accident on to the next side of a divided highway, or a different part of a difficult intersection. Some accident systems used by police are vehicle-based, which of course makes it impossible to actually record the location of the accident. GPS systems that require an officer to write the coordinates suffer from transcription errors, but those that will actually transmit the coordinates to the agency's RMS are expensive.



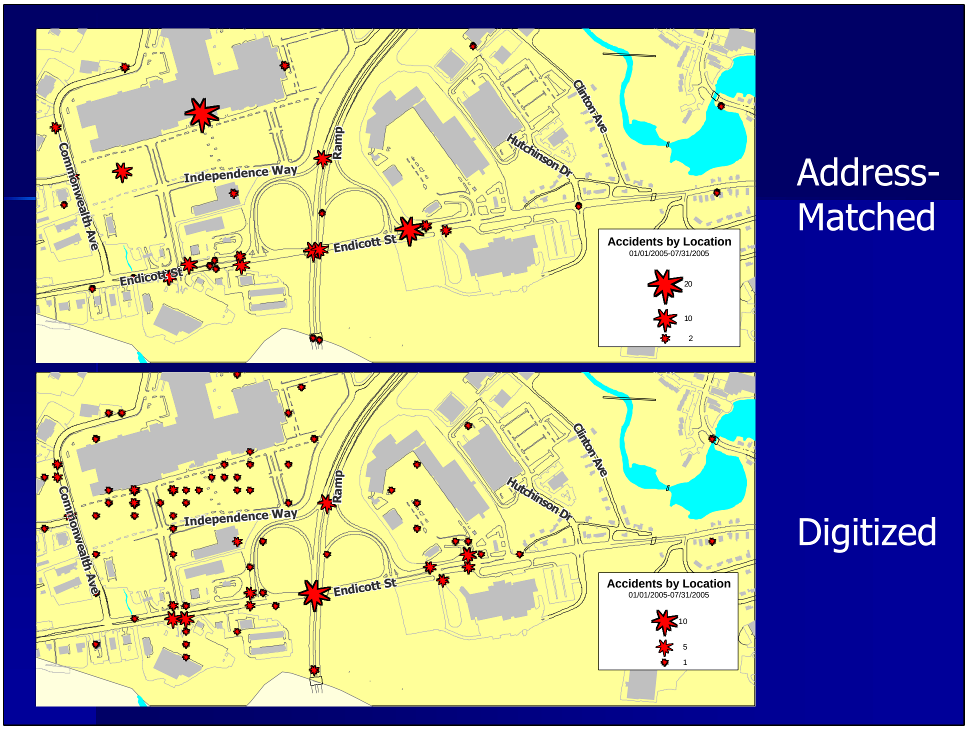
Ultra-accurate address matching was my first attempt to achieve better precision. I gave every ramp and sub-ramp its own name, then looked at the officer’s accident report and overwrote the address data received from CAD with a more precise location based on my coding scheme. As you might imagine, it was very time consuming and complicated.



Eventually, I realized that what I was doing was more complicated than if I simply used the officer’s diagram of the accident to manually digitize the accident’s location. This is the system we use now (again, an intern handles much of the work): open up a high-definition MapInfo workspace, with edge-of-pavement files, building footprints, telephone poles, and other features; look at the officer’s diagram; and manually draw a “pin” at the accident’s location on the MapInfo workspace, adding it to a layer called “Accidents.” The intern then uses the “info” tool to add the accident’s Incident Number to the attribute table. This links to the accident database.



Another example at a different location. This driver ran into a telephone pole, and we were able to use a vector map of telephone poles to pinpoint the exact location of the accident.



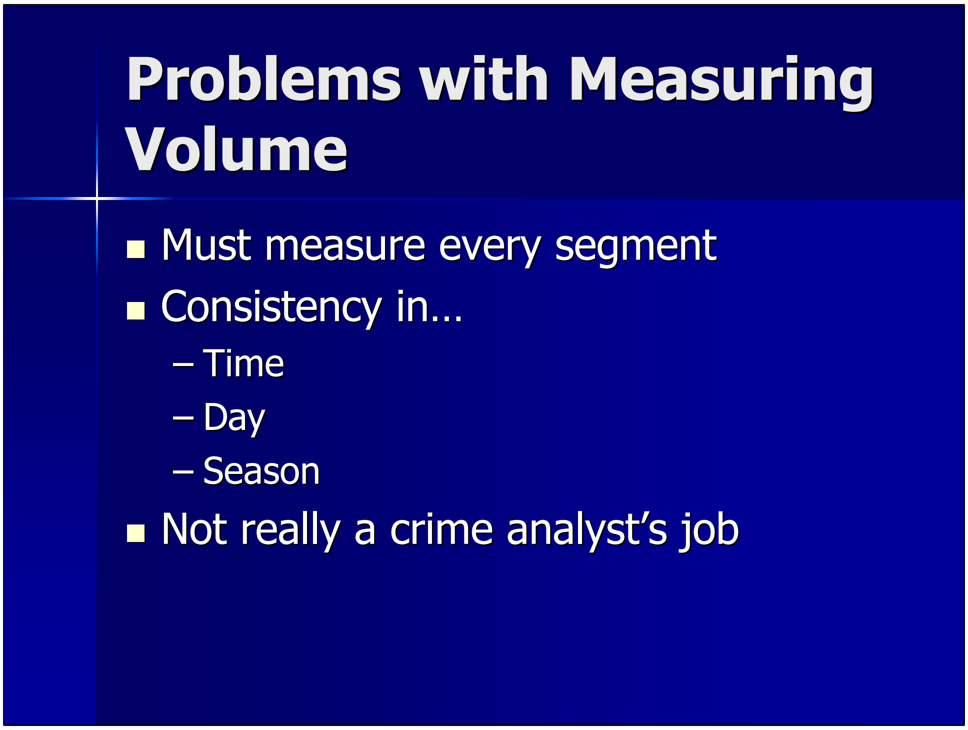
These two maps show the difference between accident data that is address-matched (to street centerline files) and data that is digitized. (I got some comments about the background color, and I again ask you to remember that I am color-blind.) The top example shows a huge number of accidents at the front door of the shopping mall, but in the bottom example we see how they are dispersed throughout the parking lot.

When I showed this map, the question arose: if I'm identifying accident locations by digitizing them, how do I aggregate them into proportional symbol maps? The chances of digitizing even two points on the exact same coordinate is very low. The answer is that I create the proportional symbol map using a layer of very small grid cells that aggregate accidents NEAR each other in the same cell. The width of the cells is only 25 feet, so accidents really need to be right on top of each other to get counted in the same cell.

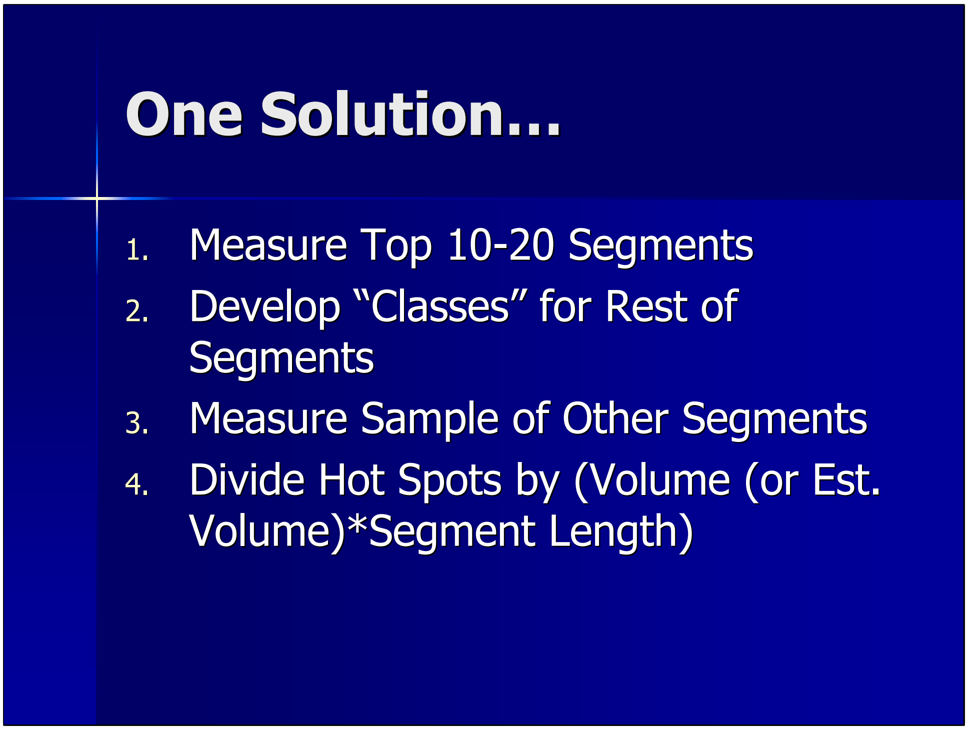
Normalizing By Volume

Location	2005 Accidents	Avg. Daily Volume	Accidents Per 1000
State & Main	140	28,000	5.00
First & Elm	100	16,000	6.25
152 Meadow	60	500	120.00
Fifth & Park	30	25,000	1.20
5200 Ohio	12	200	60.00

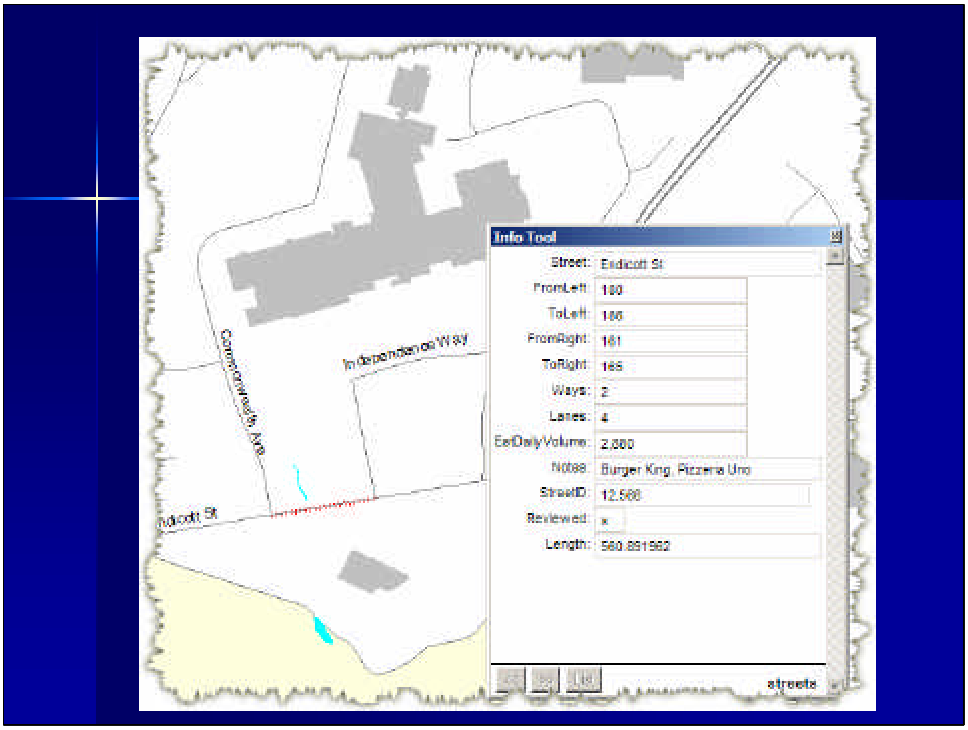
These are some extreme examples of what happens when we don't normalize by traffic volume. Here we see that State & Main actually isn't so bad, given how many cars a day it handles. 152 Meadow Street, on the other hand, has a serious problem.



But measuring average daily volume is difficult. Since different segments of the same street can have different traffic volume, we actually have to measure every *segment* in order to get an accurate picture—as if measuring the volume on every street wasn't enough work! When we take traffic volume measurements, we have to try to be consistent with time, day, and season—it wouldn't be fair to measure one street from 02:00-03:00 on a winter Tuesday and another from 17:00-18:00 on a summer Saturday. Finally, it's not really a crime analyst's job to measure traffic flow, but if the town or city isn't already doing it, who else will?



Obviously, measuring every street is impossible, let alone every segment, so here’s a potential solution: measure the top 10-20 accident segments so that you have known volumes for your “worst” areas. They develop a class system to rank the rest of your streets—I have 18 classes from a major U.S. highway to a small residential cul-de-sac. Measure a sample of segments in each class and generalize this volume to the rest of the segments in the class. Now divide your hot spots by the estimated volume * the length of the street segment, which your GIS program can generate.



An example. This street segment, just in front of the shopping mall and right in front of Burger King and Pizzeria Uno, has an estimated daily volume of 2,880 cars and a length of 560.89. I will divide the number of accidents on this segment by 1615363.2 to "normalize" it.

Some Normalized Results

	A	B	C	D	E	F
1	Top Accident Segments in 2004, Normalized by Volume					
2	**Segment**	**Acc. Total**	**Est. Volume/Day**	**Length (ft)**	**Acc./ Volume/ Length*100000**	**Notes**
3	50-230 Independence Way	76	2675	2746.38	1.03	Shopping Mall/parking lot
4	100-139 Endicott St	34	1295	981.7	2.67	Shopping Plaza/Difficult Entry & Exit
5	75-103 Newbury St	33	3010	1228.27	0.89	Route 1--No lights, two businesses
6	107-136 Andover St	31	1515	863.33	2.37	Route 114--Auto Dealer
7	260-298 Andover St	26	1230	648.61	3.26	Route 114--Bad intersection to office park
8	155-161 Andover St	24	1515	459.12	3.45	Route 114--two restaurants
9	139-148 Andover St	22	1515	314.69	4.61	Route 114--Auto dealer, two stoplights
10	1-100 Brooksby Village Dr	20	1170	1158.98	1.47	Wal-Mart/parking lot
11	87-101 High St	20	970	498.34	4.14	Off Route 128
12	50-51 Elliott St	15	720	464.24	4.49	Off Route 128
13						

Here are the results of the normalization for the top 10 hot spots in Danvers. Note that in Column E, I didn't represent the formula well, but

Accidents/Volume/Length*100,000

Is the same as

Accidents/(Volume*Length)*100,000

I threw in some notes to explain why I think the normalized volume came out the way it did. The "highest" location is a segment of Route 114 that has two auto dealerships and a couple of stoplights. It's a short segment with a moderate traffic volume, but all the left turns across many lanes into the auto dealership lots give rise to many accidents, as do the stopping and slowing at lights. The "lowest" location is a segment of Route 1 that has no stoplights and only two businesses. It carries a huge volume of cars per day, but there is little that would cause an accident here; most cars are just zooming through.

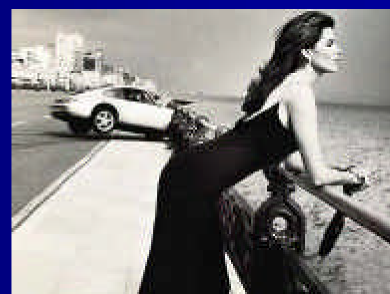
Cause Analysis

- Sign/Light Violations
- Alcohol/Drugs
- Tailgating
- Weather
- Speed
- Unsafe Left Turns
- Medical
- Impairment

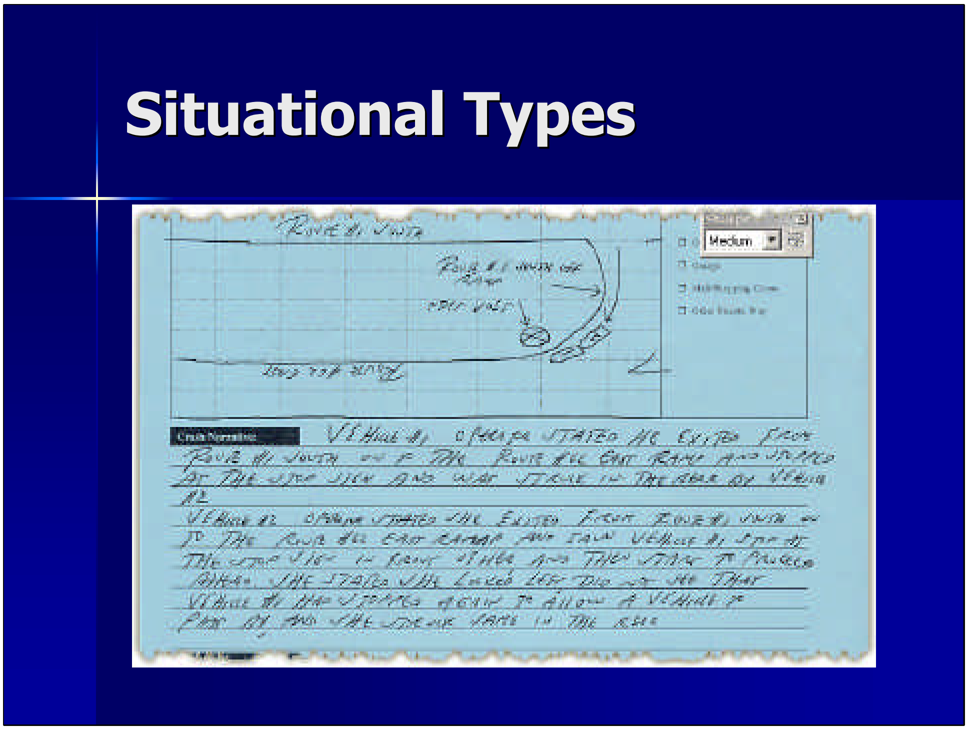
Finally, we have to consider some causes of traffic accidents. In police departments, we might analyze accidents to direct selective enforcement. But it doesn’t make sense to send police officers just to the top “hot spots” unless the causes of the accidents at those “hot spots” are enforceable violations. Look at the list of potential causes on this slide and the next one. Very few of them are “enforceable” in the sense that officers could watch for violations and cite drivers.

Cause Analysis

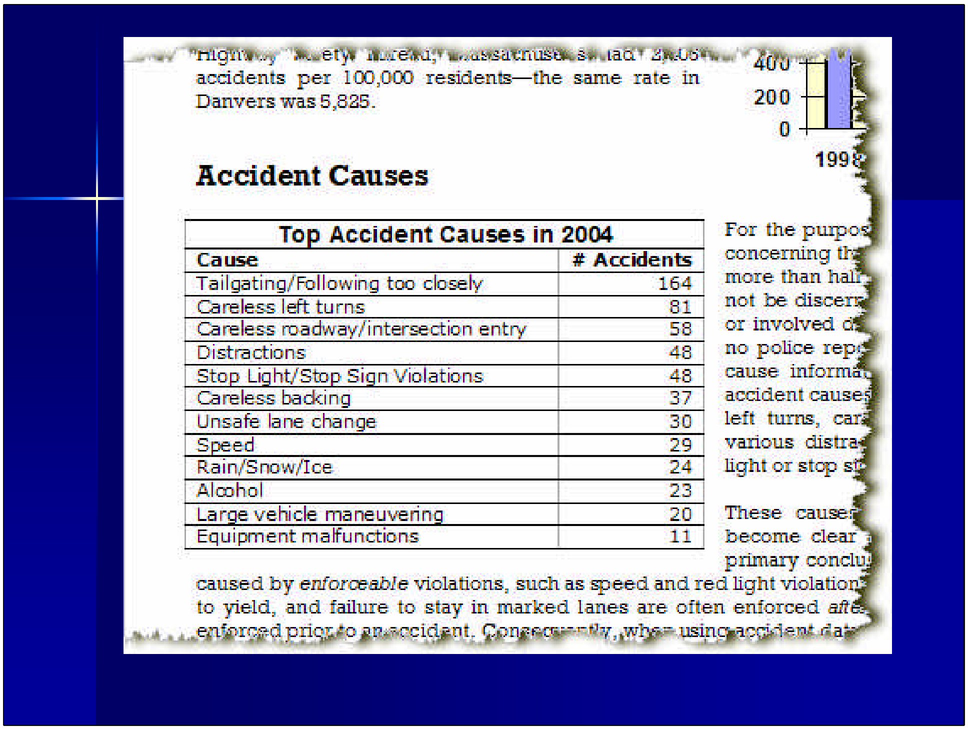
- Distractions
- Unsafe Roadway/ Intersection Entry
- Backing
- Animal
- Jaywalking/Biking
- Equipment Malfunction



Some more causes. Sorry if the photograph offends, but I thought it was a good example of an accident caused by “distraction.”



Certain accident causes form a unique *modus operandi*. This is what I call “merge mirage,” when one driver rear-ends another on an on ramp because he is convinced that the other driver has “already gone.”



accidents per 100,000 residents—the same rate in Danvers was 5,825.

Accident Causes

Top Accident Causes in 2004	
Cause	**# Accidents**
Tailgating/Following too closely	164
Careless left turns	81
Careless roadway/intersection entry	58
Distractions	48
Stop Light/Stop Sign Violations	48
Careless backing	37
Unsafe lane change	30
Speed	29
Rain/Snow/Ice	24
Alcohol	23
Large vehicle maneuvering	20
Equipment malfunctions	11

For the purpos
concerning th
more than half
not be discern
or involved d
no police rep
cause informa
accident causes
left turns, car
various distra
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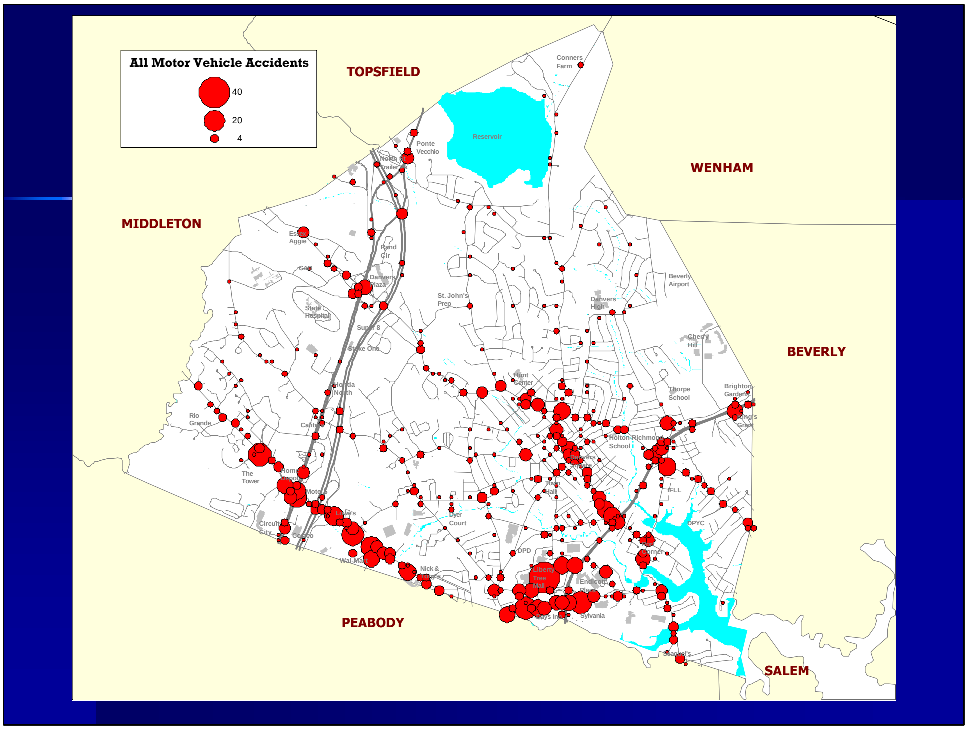
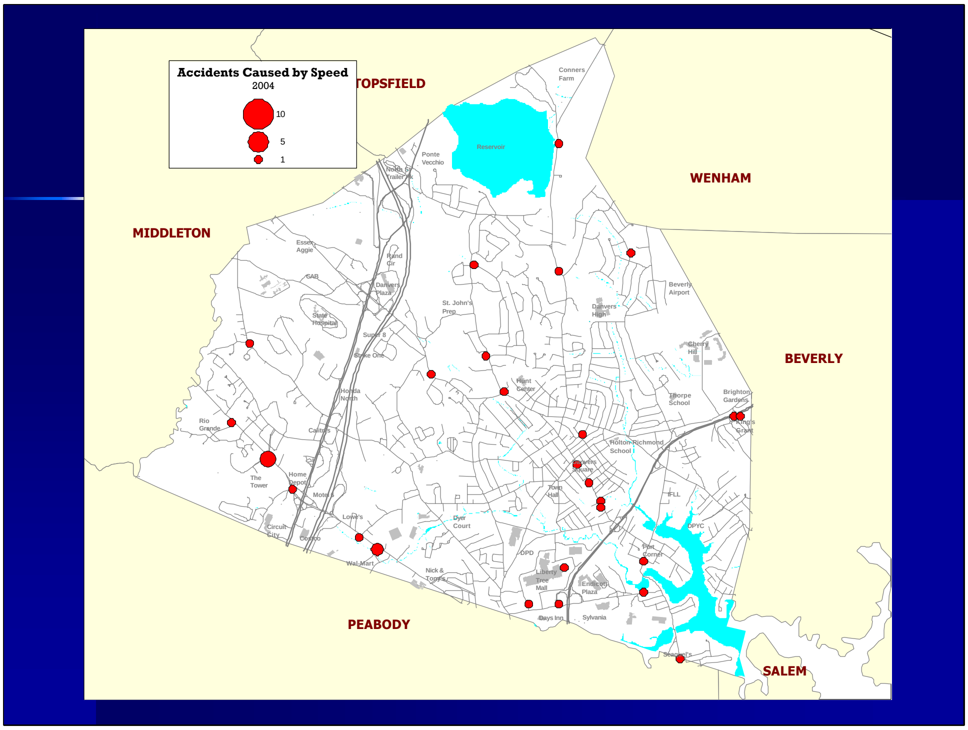
These causes
become clear
primary conclu

caused by *enforceable* violations, such as speed and red light violation
to yield, and failure to stay in marked lanes are often enforced afte
enforced prior to an accident. Consequently, when using accident da

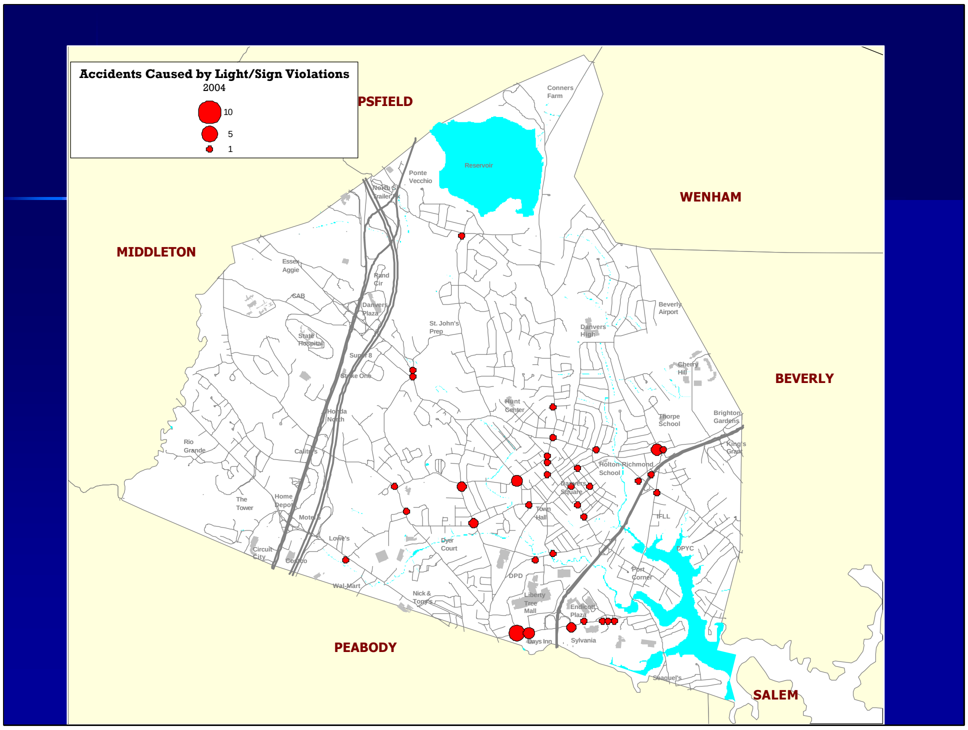
We can use accident causes in community reports to help alert the public to risky driving behaviors. In Danvers, with its congested streets, tailgating or following too closely is the number one accident cause. If more people were aware of this, they might not follow so closely.

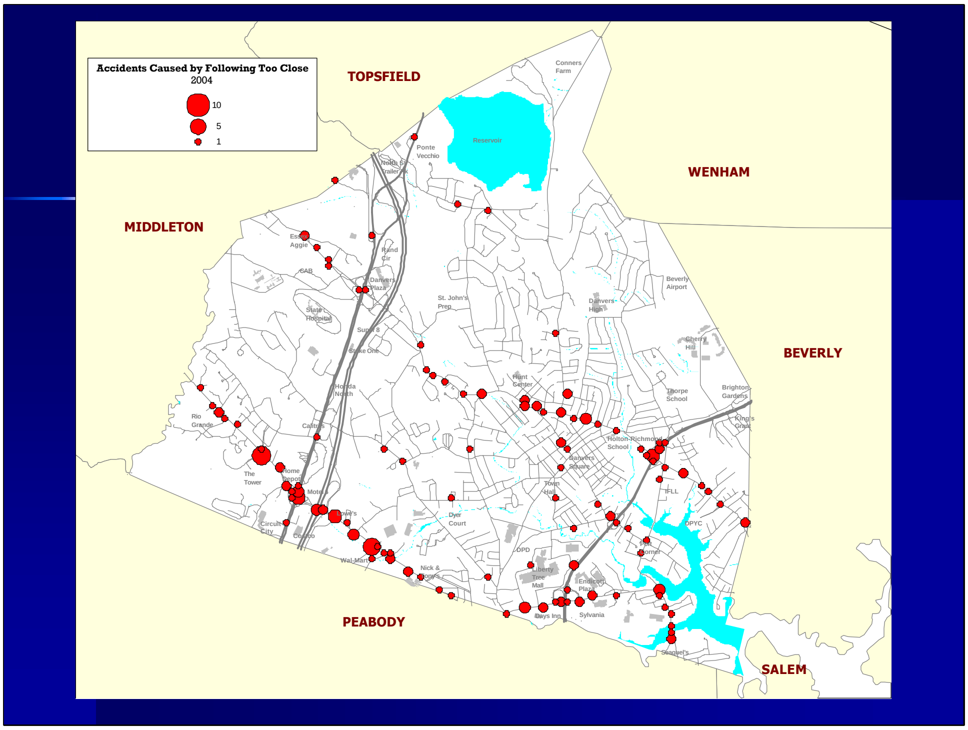


Here, then is the difference between showing a map of all accident locations, which is fairly worthless…



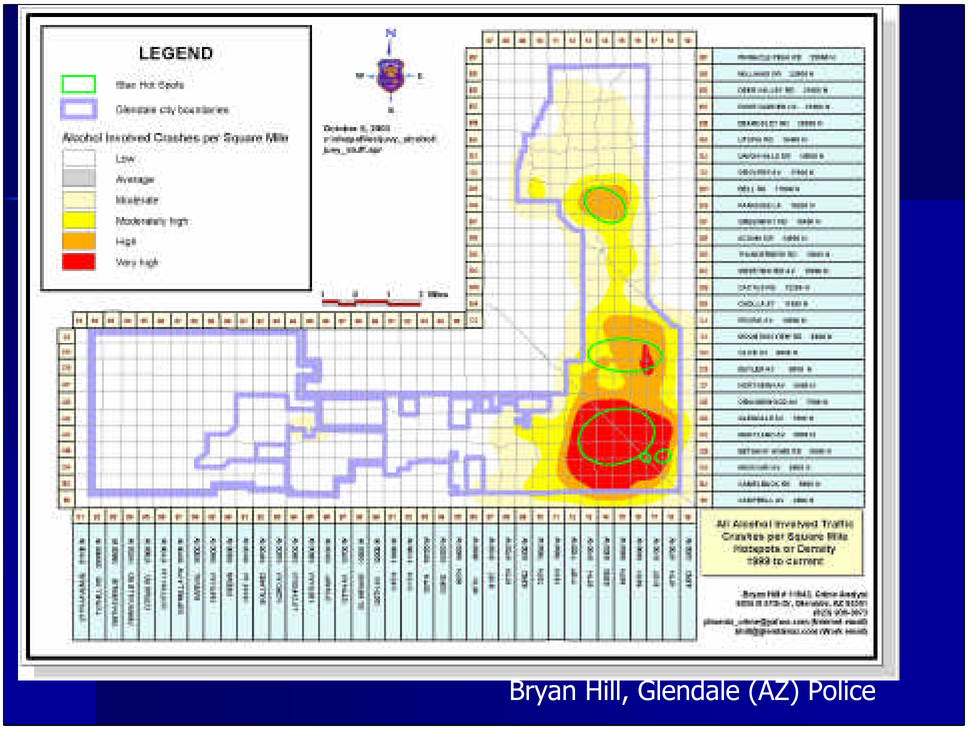
…and showing a map of accident locations by cause. This one looks at accidents specifically caused by speed. Here we have a much more limited number of hot spots that makes it easier to direct enforcement.


Accidents Caused by Light/Sign Violations
2004
10
5
1
PSFIELD
WENHAM
MIDDLETON
BEVERLY
PEABODY
SALEM
Conners Farm
Reservoir
Ponte Vecchio
St. John's Prep
Danvers High
Beverly Airport
Thorpe School
Brighton Gardens
Holten-Richmond School
Town Hall
Home Depot
Rio Grande
The Tower
Wal-Mart
DPD
Liberty Tree Mall
Sylvania



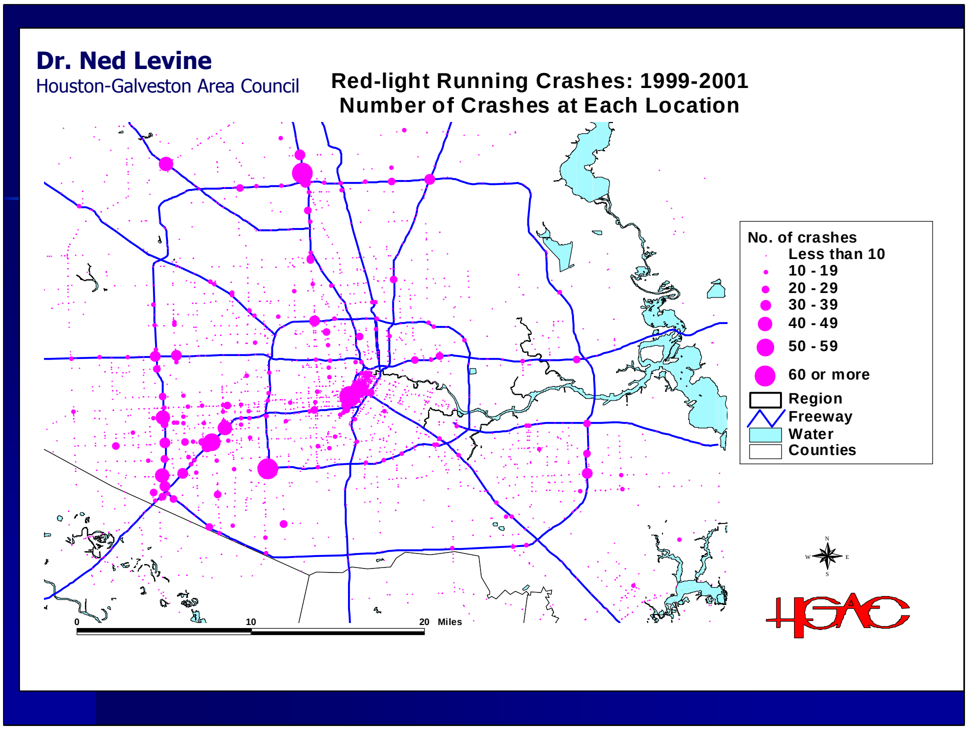
And another map of accidents caused by following too closely. As we might imagine, these accidents are most common along some congested routes with lots of stop lights and signs.

All of these maps have been proportional symbol maps, which I think depict traffic accident hot spots better than other maps. We have some more examples, though…

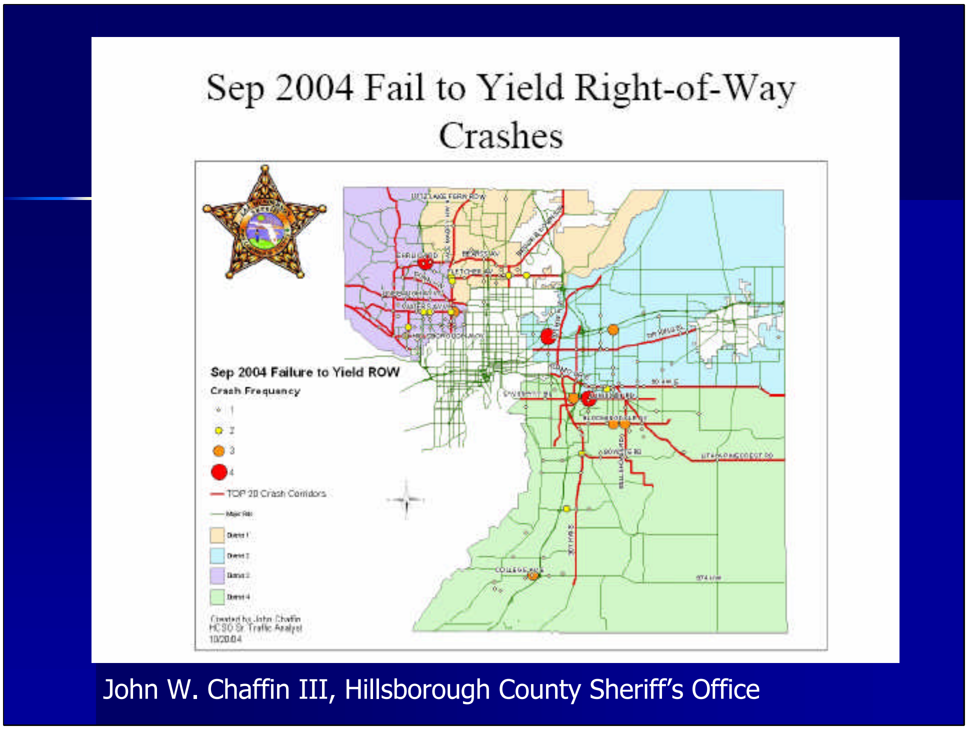


This map, provided by Bryan Hill of Glendale, Arizona, shows hot spots for alcohol-involved accidents. I don’t normally recommend surface density maps for accident hot spots, since most accidents happen at specific locations for specific reasons. The fact that one intersection is a hot spot does not mean that nearby intersections are at a greater risk for accidents, so this type of mapping I think is invalid in most cases.

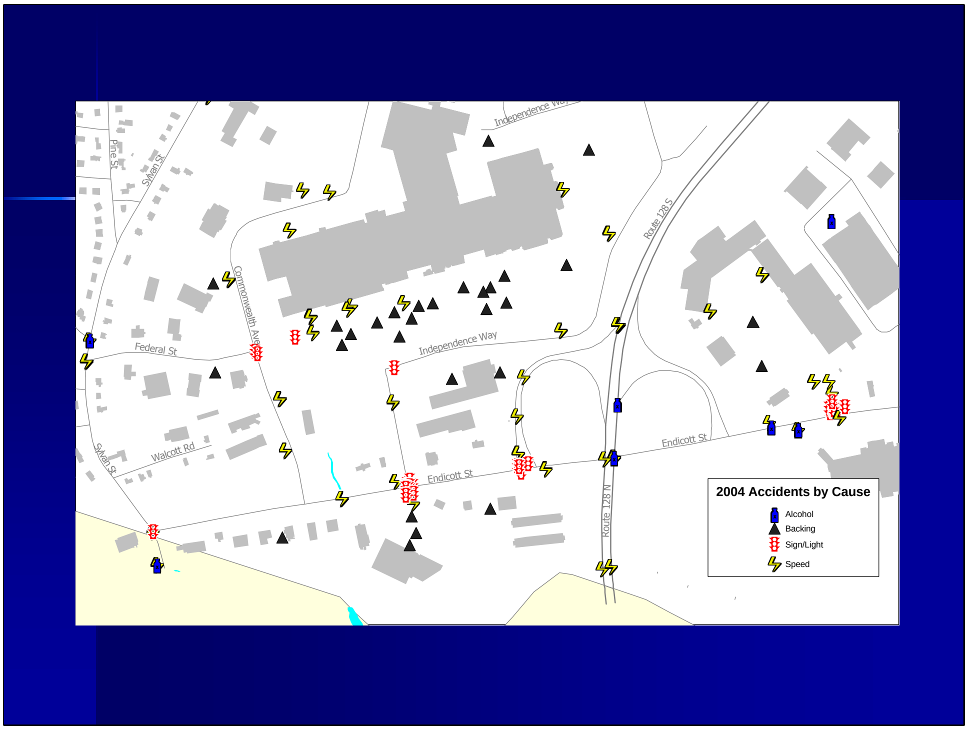
The exception is alcohol-involved accidents, as in the case of Bryan’s map. Drunk driving accidents happen at the location that the drunk driver finally lost control or encountered another car, so they are less a function of a specific place than a general area. For that reason, I think Bryan’s map is a very good one, focusing officer efforts to find drunk drivers in a fairly concentrated area.



Ned Levine provides this example of a graduated symbol map, showing hot spots caused by running red lights. The graduated symbol size allows us to quickly identify hot spots for enforcement.



And another proportional symbol map from Hillsborough County, courtesy of John Chaffin. These are caused by failure to yield the right of way, another enforceable violation.



I threw this together at the last second for the presentation, so I apologize for the overall sloppiness. This illustrates how we can use a point symbol map to show both hot spots and specific causes. Here we see the difference between accidents caused by careless backing in parking lots versus accidents caused by red light violations.

I finished the presentation with a very, very funny story that would take too long to type (and in any event depends on my unique style of comic delivery), so you'll just have to ask me about it in person some time. I hope these ideas have been valuable to you; if you need anything else, feel free to give me a call or e-mail.